ABSTRACT

A high voltage electrostatic spray coating power supply which turns-off automatically when an overvoltage and/or overcurrent is detected, thereby reducing electrical shock and ignition hazards when spraying in an explosive atmosphere. Included is an unregulated DC supply, a DC voltage regulator, an inverter, and a multiplier of the capacitor/diode type which applies high DC voltage to an electrostatic spray gun. Ground return current from the multiplier output to a common internal ground lead is monitored and if it exceeds a predetermined selectable maximum is effective, via a turn-off circuit, to a) turn-off the DC regulator and b) short-circuit the regulator output and inverter input to the common ground. This prevents power transfer between the unregulated DC source and the voltage multiplier, as well as discharges electrical energy stored in the regulator smoothing capacitors and the multiplier transformer. An overvoltage circuit is also included to independently turn-off the power supply when the regulator output voltage exceeds a predetermined maximum.

7 Claims, 1 Drawing Figure
HIGH VOLTAGE POWER SUPPLY WITH OVERCURRENT PROTECTION

BACKGROUND OF THE INVENTION

This invention relates to power supplies and particularly to high voltage power supplies for use in electrostatic spray coating equipment and the like.

In the field of electrostatic spray coating, a material applicator such as a spray gun or other apparatus is provided for spraying a material, such as powder or liquid, onto an object. The spray gun includes a probe located at or near the nozzle which is maintained at a very high DC voltage which is typically between 50 and 100 Kv. The voltage at the probe charges the coating material as it passes through the nozzle thereby increasing the coating efficiency because the charged material is attracted to the object being coated which is maintained at ground potential.

The voltage at the spray gun probe is developed by a power supply which is generally located at some distance from the spray gun itself. A coaxial cable or similar high voltage cable interconnects the high voltage power supply with the spray gun probe.

Because the voltage at the spray gun probe is typically between 50 and 100 Kv., safety precautions are necessary to prevent accidental electrical shock to an operator who must handle the spray gun during spraying operations as well as to prevent arcing at the spray gun which may cause an explosion if the spray gun is operated in an explosive atmosphere. In the prior art, one precaution taken has been to provide a series electrical resistance between the high voltage power supply and the spray gun probe to thereby limit the maximum current which can be delivered from the power supply to the spray gun probe. Consequently, if the operator should accidentally touch the spray gun probe, the maximum current that he would receive by such accidental contact is limited to prevent electrical shock. The resistor also limits the current in the spray gun probe to thereby reduce the extent of arcing should the spray gun probe accidentally touch a grounded object.

Recently, increased interest in industrial safety has pointed out that the series resistor alone does not provide as much safety as would be desirable for electrostatic spray guns. Particularly, the problem of arcing between the spray gun probe and another object, while reduced, is not eliminated by use of the series resistor. While the resistor in series with the spray gun probe has served to reduce the magnitude of arcing, if the probe should actually touch a grounded object, a small arc will occur just before the probe contacts the object. Additionally, an arc will also occur after the probe is removed from contact with the object. Although the magnitude of this arc is small because the series resistor limits current flow, the arc itself does occur and this may cause an explosion if the spray gun is being operated in an explosive atmosphere, e.g. where the spray material is a solvent based point.

Some prior art power supplies of the voltage multiplier type have overcurrent shutoff circuits which turn off the high voltage whenever the current flowing into the spray gun probe exceeds a predetermined maximum value. The overcurrent condition is usually determined by measuring the current flow into the voltage multiplier from the inverter circuit in typical power supplies. Because the current flow into the voltage multiplier is an AC current, overcurrent detection by measuring current flow into the voltage multiplier does not provide a consistently fast manner for determining the exact time when an overcurrent condition occurs. The reason for this is that the AC current flow into the voltage multiplier may be zero at the instant of time when an arc occurs. The overcurrent detector will not detect the overcurrent condition instantaneously but requires time to elapse until the AC current rises above the maximum value which triggers the overcurrent detector. Then the power supply can be shut down by the overcurrent detector. If, however, the AC current flow into the voltage multiplier is near its maximum when an arc occurs, the overcurrent detection will occur almost instantaneously after the arc occurs. As such, by monitoring AC current to detect overcurrent conditions, a time delay may occur between the time when an arc occurs and the time when the overcurrent condition is detected. This time delay slows the speed at which the power supply can be turned off. Consequently, the prior art circuits cannot reliably turn off the power supply instantaneously because the overcurrent condition cannot be reliably detected instantaneously.

Other prior art overcurrent detectors for shutting down a power supply respond to AC rms current and rms current detectors do not respond as quickly to current changes as instantaneous current detectors. Consequently, the rms current detector approach to power supply shut down on detection of overcurrent is slow to detect the overcurrent condition which means the power supply is shut down slowly also.

Additionally, the prior art electrostatic spray coating systems which employ a hand held spray gun have utilized a trigger switch mounted on the gun to actuate the high voltage power supply and the spraying mechanism. Typically, the voltage appearing across this trigger switch is quite high, around 110 volts, so that when the trigger itself is closed, a small arc occurs as the switch contacts close. In order to prevent this arc from causing an explosion, special precautions have been taken to isolate the trigger switch on the spray gun from the explosive atmosphere. Typically, these precautions have been unduly costly and add unnecessary bulk to the spray gun.

OBJECTS OF THE INVENTION

In view of the foregoing difficulties, it is the primary objective of the invention to provide a high voltage power supply for electrostatic spray coating applications which reliably and instantaneously detects the overcurrent conditions at the spray gun probe and shuts off the supply when probe overcurrent is detected thereby reducing the danger of electrical shock and arcing.

BRIEF DESCRIPTION OF THE INVENTION

One aspect of the invention is predicated on the concept of quickly and reliably detecting overcurrent conditions in a very high voltage power supply of the voltage multiplier type for electrostatic spray coating applications by detecting overcurrent at a point in the circuit where the probe current can be measured directly.

A further aspect of the invention is predicated on the concept of providing a very high voltage power supply having a voltage regulator, an inverter circuit powered by the regulator, a voltage multiplier powered by the inverter which produces a spray gun probe voltage and an overcurrent detector responsive only to excessive
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spray gun probe current to turn off the voltage regulator, short circuit the voltage regulator output and short circuit the inverter circuit input to thereby reduce the danger of arcing and electrical shock.

A further aspect of the invention is predicated on the concept of providing a power supply of type described above which includes an overcurrent detector which turns off the power supply in the same manner as the overcurrent detector when the spray gun probe voltage becomes excessive.

More particularly in a preferred embodiment, the power supply includes a DC voltage regulator for producing a regulated DC voltage from an unregulated power source. The regulated voltage powers an inverter circuit which produces an intermediate voltage at a high frequency. This intermediate voltage source powers a voltage multiplier which produces a high DC voltage that is applied to the probe of an electrostatic spray gun. An overcurrent detector measures the probe current directly by monitoring the ground return current from the voltage multiplier. If the ground return current exceeds a predetermined value, the overcurrent detector is effective to short circuit the output of the voltage regulator, to short circuit the input of the inverter circuit and to turn the regulator off. An overvoltage detector monitors the output of the regulator which is directly related to spray gun probe voltage. If the regulator output voltage exceeds a predetermined maximum, a signal is developed which is independently effective to turn off the supply by short circuiting the regulator output, to short circuit the input of the inverter circuit and to turn off the regulator.

According to a further aspect of the invention, the danger of explosion due to arcing of a spray gun trigger switch is reduced. The trigger switch of the invention controls an electronic switch for turning on and off the power supply so that the maximum voltage across and current through the trigger switch of the invention is very low. Consequently, the danger of explosion due to trigger switch arcing is reduced.

DESCRIPTION OF THE DRAWINGS

The foregoing objects, and advantages of the invention will become more clear from the following detailed description of a preferred embodiment thereof taken in connection with the drawing which forms a part of the original disclosure wherein the sole FIGURE is a schematic circuit diagram of the power supply.

DETAILED DESCRIPTION

Referring now to FIGURE, a high voltage power supply for electrostatic spray coating applications of the present invention is shown generally at 10. The power supply 10 includes an intermediate voltage section shown within the dotted line 11, and a voltage multiplier circuit 12 for multiplying the AC voltage developed by the intermediate voltage section 11 into a very high DC voltage. The voltage multiplier circuit 12 may be a conventional voltage multiplier circuit, however, in a preferred embodiment of the invention, the voltage multiplier circuit 12 is of the diode/capacitor voltage doubler type designed according to the description contained in the copending patent application entitled "Quick Connect Modular Voltage Multiplier" by Robert E. Sandorf which was filed on Dec. 13, 1973, and has a Ser. No. 424,546. The very high DC voltage output of the voltage multiplier 12 is electrically connected via a coaxial cable 13 to a spray gun probe 14 located on an electrostatic spray gun 15. The spray gun probe 14 is located near the spray gun nozzle and charges particles as they are sprayed from the spray gun 15 in a manner well known in the art of electrostatic spray coating.

The intermediate voltage power supply section 11 has a plug 20 or other suitable connector for connecting an external AC power source to the low voltage section 11. In a preferred embodiment, this AC power source is a 60Hz source having a voltage which will produce approximately +50 volts at the output 21 relative to the negative output lead 23 of a bridge rectifier circuit 22. The negative output lead 23 is connected to a common internal ground 24. The bridge rectifier circuit 22 is any conventional bridge rectifier circuit using diodes which will convert AC power to unregulated DC power. The unregulated DC power at the output 21 of the bridge rectifier 22 is filtered by a large filter capacitor 25 to thereby produce an unregulated DC voltage on the wire 26. The wire 26 is connected to the power input of a voltage regulator circuit shown within the dotted line 27. The voltage regulator circuit 27 is a conventional voltage regulator circuit preferably of the series regulator type which produces a practically constant DC voltage at the output point 28 which is regulated to between 0.1 and 0.3 percent regulation. The voltage at the output point 28 is adjustable, however, according to two options available in the circuit. According to one option, a fixed resistor 30 is series-connected between electrical connection points 31 and 32. The value of this resistor 30 is selected so that the adjustable resistor 33 can be adjusted to produce the voltage desired at the output point 28. For some applications, the resistor 30 may be replaced by a jumper wire.

According to the second option, an adjustable resistor 34 is connected between the connection point 31 and the connection point 35. This adjustable resistor 34 is adjustable from the ground supply console (not shown) permitting the user to adjust the voltage at the point 28 and, therefore, adjust the voltage at the spray gun probe 14 as will become clearer later. The adjustable resistor 33 is not adjustable from the console but is preset to establish the maximum voltage which may be set by adjustment of the resistor 34 and, thus, the maximum spray gun probe 14 voltage is also preset. According to the two above-mentioned options, the output voltage at point 28 can be either fixed or adjustable. For the fixed voltage output, the resistor 30 is installed while for the adjustable voltage output the resistor 34 is installed. Both resistors 30 and 34 are never simultaneously installed.

The voltage at the base of the transistor 36 is operative to control the operation of the voltage regulator 27. When the base voltage of this transistor 36 is approximately zero volts, the series regulator 27 is turned off and the voltage at the output point 28 is substantially zero volts. On the other hand, when the voltage at the base of the transistor 36, as controlled by the biasing resistor 37 and the transistor 38 is positive, the voltage regulator 27 is operative to produce a regulated positive DC voltage at the output point 28.

A transistor 40 is connected between the base of the transistor 36, which comprises the control input to the voltage regulator 27, and the common internal ground
24. Whenever the transistor 40 is conducting, the voltage drop thereacross is substantially zero volts so the voltage at the base of the transistor 36 is essentially zero volts. Therefore, when the transistor 40 conducts, the series regulator 27 is turned off and produces zero volts at its output point 28.

Series connected resistors 41, 42 and 43 bias the transistor 40 to conduct thereby causing the voltage at the base of the transistor 36 to be essentially zero volts. A normally open switch 44, preferably located at the spray gun 15, is connected in parallel with the resistors 42 and 43. When this switch 44 is closed by actuation of the trigger on the spray gun 15, the transistor 40 is turned off because its base becomes grounded thereby causing the voltage at the base of the transistor 36 to go positive permitting the voltage regulator circuit 27 to operate and produce a positive regulated DC voltage at its output point 28.

Since the bias circuitry for the transistor 40 comprises the series connected resistors 41, 42 and 43, the maximum voltage appearing across a switch 44, which is connected in parallel with the resistors 42 and 43, is approximately 4 volts when the voltage on the wire 26 is approximately 40 volts. Because the maximum voltage across the switch 44 contacts is 4 volts, the extent of arcing at this switch 44 when it is opened and closed is very small thereby substantially reducing the danger of explosion due to arcing at the switch 44 when the spray gun is operated in an explosive atmosphere. Additionally, since the extent of arcing across the switch 44 is so small, the isolation of the switch from the environment need not be as extensive as has been heretofore been required thereby reducing the cost and weight of the spray gun 15.

The output of the voltage regulator circuit 27 is filtered by a large filter capacitor 45 connected between the output point 28 and the common internal ground 24.

An isolation diode 46 is connected to the output point 28 of the series regulator circuit 27. This diode 46 permits the positive voltage at the output of the series regulator 27 to be connected to the remainder of the power supply circuitry. The isolation diode 46 also isolates the series regulator 27 from positive transient voltages developed by the circuitry connected at point 47.

The voltage at point 47 is filtered by an additional filter capacitor 53. This capacitor 53 has a smaller capacitance and a higher frequency response than the capacitor 45 and is provided to filter high frequency signals which appear at the point 47 to thereby reduce the effects of these signals on the other circuitry.

An inverter circuit 50 is connected to and powered by the DC voltage at point 47. The inverter circuit 50 is a conventional power inverter for converting DC to AC power and includes, in a preferred embodiment, two transistors 54 and 55 wired in circuit with a center tapped primary winding 56 and a feedback winding 57 of a cup-core transformer 58. The transistors 54 and 55 in the inverter 50 conduct alternately through the primary winding 56 of the transformer 58 when DC power is present at point 47. In the preferred embodiment the frequency at which these two transistors 54 and 55 alternately conduct is approximately 10kHz which is determined primarily by the inductance of the transformer primary 56, the inductance of the feedback winding 57 and the natural capacitance of these windings. It is desirable, however, to have the inverter circuit 50 oscillate at a high frequency so that the voltage multiplier can be made with small capacitors. As such, the stored charge in the voltage multiplier is smaller than in other voltage multipliers thereby reducing the danger of shock and arcing due to stored energy in the voltage multiplier.

In the preferred embodiment of the invention, the secondary winding 60 has a sufficient number of turns so that the intermediate voltage appearing across this winding is approximately 8kV peak-to-peak. This 8kV peak-to-peak voltage is applied to the input of the voltage multiplier 12. As indicated earlier, the voltage multiplier 12 multiplies the input voltage to develop at its output a DC voltage having a very high magnitude which, in the preferred embodiment, is in the order of 100kV. As such, whenever a positive voltage is applied to the point 47, the inverter circuit 50 will produce across the secondary winding 60 of the cup-core transformer 58 an 8kV peak-to-peak voltage which is converted by the voltage multiplier 12 into a high DC voltage that is transmitted via a coaxial cable 13 to the probe 14 at the spray gun 15.

The positive voltage at point 47 directly controls the magnitude of the voltage multiplier output. When the voltage at point 47 goes up, the probe voltage goes up and vice versa.

A high voltage indicator driver circuit 51 is provided to power an indicator lamp 61, located on the system console (not shown), whenever high voltage is present at the spray gun probe 14. The indicator driver circuit 51 includes a transistor 62 whose emitter is connected to the common internal ground 24 and whose collector is connected in series with the lamp 61 and a current limiting resistor 63 to the positive voltage output 21 of the bridge rectifier 22. Series connected biasing resistors 64 and 65 for controlling the transistor 62 are connected between the point 47 and the common internal ground 24 and cause the transistor 62 to conduct whenever a positive voltage is present at point 47. As such, the lamp 61 is ignited whenever a positive voltage is present at the input to the inverter circuit 50 thereby providing the operator with a visible indication when high voltage is present at the spray gun probe 14.

The power supply of the invention includes an overcurrent detector shown within the dotted line 70. This overcurrent detector is designed to generate a signal to shut down the power supply when the ground return current through the wire 71 from the voltage multiplier 12 exceeds a predetermined maximum value. The current passing through the ground return wire 71 is equal to the probe current but does have many high frequency noise components which must be filtered out to prevent triggering the overcurrent detector 70 and cause the power supply to shut down unnecessarily. This filtering is provided by a high frequency filter shown generally at 72 which comprises a capacitor and a resistor connected in parallel between the wire 71 and the common internal ground 24. Because the overcurrent detector 70 measures the return current from the voltage multiplier 12, overcurrent conditions at the spray gun probe 14 are detected directly and are not masked, as in prior art approaches, by the AC current in the power inverter circuit. In fact, the overcurrent detector of the invention will generate the overcurrent signal and shut down the series regulator 27 in less than
The ground return current flows through the wire and the isolation diode to a resistor and develops a voltage thereacross which has a magnitude directly proportional to the ground return current. A zener diode is parallel connected across the resistor to prevent the maximum voltage appearing at the point due to high ground return currents from exceeding a value which might cause circuit damage to the connected integrated circuit. The integrated circuit is preferably an operational amplifier manufactured by the Fairchild Camera and Instrument Company type number U97T741393 which has been wired, as indicated in the FIGURE as a differential amplifier. Whenever the voltage at the input pin 3 which is connected to the point exceeds the voltage at the input pin 2, the voltage at the output pin 6 goes positive. On the other hand, when the voltage at the input pin 3 is less than the voltage at the input pin 2, the voltage at the output pin 6 is approximately zero volts. As such, by adjusting the voltage at the input pin 2, the operation of the integrated circuit 77 can be adjusted to produce at its output pin 6 a signal indicating when the ground return current exceeds a predetermined maximum value.

The input pin 2 to the integrated circuit 77 has an adjustable biasing circuit connected thereto which permits the voltage thereat to be preset so that the predetermined maximum ground return current necessary to cause the output voltage at pin 6 to go positive can be selected. This biasing circuit includes a resistor, an isolation diode, an adjustable resistor and two fixed resistors and connected in series with the adjustable resistor. The resistor is connected to the point which has a constant positive DC voltage as controlled by the zener diode. Consequently, the series-connected resistors, and are a voltage divider between the constant voltage appearing at the point and the common internal ground. By adjusting the setting of the adjustable resistor, the positive voltage appearing at the variable tap can be adjusted to any desirable value. As such, the predetermined maximum ground return current which causes the output pin 6 to go positive can be adjusted.

The biasing network for the input pin 2 to the integrated circuit 77 also includes additional biasing circuitry for preventing the output of the integrated circuit 77 from going positive during the time when power supply transients occur, such as during turnon of the power supply. The transient surge current associated with power supply turnon does not cause the output of the integrated circuit 77 to go positive because the voltage at the input pin 2 is raised by a surge-protect circuit. The surge protect circuit includes a resistor, a capacitor, a zener diode, a resistor, and two diodes and 95 wired as shown in the FIGURE. When the voltage at point changes suddenly, a signal will pass through the capacitor. The positive magnitude of this signal is limited by the zener diode. Positive signals passing through the capacitor also pass through the diode and through the resistor to the pin 2 input of the integrated circuit 77, if the magnitude of the positive surge is greater than the voltage at pin 2. As such, the magnitude of the ground return current which would cause the output at pin 6 to go positive is increased during the time when the power supply voltage is turning on thereby preventing turnon transients from producing a positive signal at pin 6 of the integrated circuit 77.

The output pin of the integrated circuit 77 is connected via a wire to the overcurrent/overvoltage shutoff switch 52. This shutoff switch 52 includes a silicon controlled rectifier (SCR) connected in series with a diode 102 between the point and the common internal ground. Whenever this SCR 101 is fired, current will conduct from the point through the diode, through the SCR to the common internal ground thereby substantially short circuiting the point to the common internal ground. As such, the output of the series regulator circuit 27 and the input of the inverter 50 are shorted to ground so that additional power is not supplied to the voltage multiplier. Additionally, the stored energy in capacitors and 53 and the stored energy in the field of the transformer is quickly dissipated. Consequently, the only source of high voltage energy at the spray gun probe 14 after the overvoltage/overcurrent shutoff switch 52 is fired from the stored energy in the capacitors of the voltage multiplier. Since a high frequency inverter is used, the capacitors of the voltage multiplier are small and the high voltage stored energy is low thereby decreasing the hazard of electrical shock and arcing due to stored energy in the voltage multiplier.

The overcurrent/overvoltage shutoff switch 52 also turns off the voltage regulator circuit 27. A diode is connected between the base of the transistor and the point. When the SCR 101 conducts, the voltage at the point goes substantially to zero volts which draws the voltage at the base of the transistor down to near zero volts also. By doing so, the series regulator circuit 27 is turned off which will reduce the current flow through the SCR 101 to prevent overheating thereof.

The SCR 101 is fired, i.e., made conductive, whenever the voltage at the gate becomes positive. This condition will exist when an overcurrent condition or overvoltage condition exists. Whenever the output voltage from pin of the integrated circuit 77 goes positive, indicating that the ground return current on wire has exceeded a predetermined maximum value, this positive voltage exceeds the breakdown voltage of the zener diode by approximately 3 volts thereby causing the current to flow through the resistors and to the common internal ground. The voltage developed across the resistor is sufficiently positive to cause the SCR 101 to fire thereby short circuiting point 47 to ground. As such, whenever an overcurrent condition is detected by the overcurrent detector, power is quickly removed from the input to the voltage multiplier.

The overcurrent/overvoltage shutoff switch also turns off the power supply when an overvoltage condition is detected so that the voltage at the spray gun probe 14 cannot go substantially above the desired maximum voltage without the power supply turning off. The cause for increased voltage at the spray gun probe 14 is due to an overvoltage condition appearing at the point 47, the power input to the inverter circuit. A zener diode is connected between the point 47 and the gate of the SCR 101. Whenever the voltage at the point 47 exceeds a predetermined maximum value, the zener diode will conduct and a voltage is developed across the resistor. This voltage across the re-
sistor 106 is positive enough so that the SCR 101 will conduct. In this manner, the SCR 101 will short circuit the output of the voltage regulator 27, short circuit the power input to the inverter circuit 50 and turn off the voltage regulator 27 in the same manner as occurs when an overcurrent condition is detected by the overcurrent detector 70.

The SCR 101, once fired by a sufficiently positive voltage on the gate 103 continues to conduct current through a latching resistor 107 until such time as the SCR 101 is made nonconductive by a reset circuit. This reset circuit includes a normally open pushbutton switch 111, located on the system console (not shown). This switch 111 is connected between the point 108 and the common internal ground 24. This normally open switch 111 is the reset switch which, when closed, provides a short circuit across the SCR 101. When this short circuit occurs, the SCR 101 ceases to conduct so that, when the switch 111 is opened again, the power supply is reset to permit further actuation of the trigger switch 44 at the spray gun 15 to turn on the high voltage at the spray gun probe 14.

**TABLE OF PARTS NOT IDENTIFIED IN THE FIGURE**

| CR1-CR7 DIODE — G.E. IN5059 — MOTOROLA — IN4002 |
| CR8-CR11 DIODE — MOTOROLA MR811 |
| CR12-CR16 DIODE, IN4148 — G.E. — FAIRCHILD |
| CR19 ZENER DIODE — DICKSON IN4746 — MOTOROLA MZ1000-19 |
| CR20 ZENER DIODE, DICKSON IN4744 — MOTOROLA MZ1000-17 |
| CR21 ZENER DIODE, DICKSON IN4734 — MOTOROLA MZ1000-7 |
| CR23 ZENER DIODE, IN5241A, MOTOROLA — DICKSON |
| CR24 ZENER DIODE, DICKSON IN4756 — MOTOROLA MZ1000-29 |
| CR25, CR26 ZENER DIODE, DICKSON IN4764 — MOTOROLA MZ1000-37 |
| Q1, Q3, Q4, Q6, Q7 TRANSISTOR 2N3440 — RCA — MOTOROLA |
| Q2, Q8, Q9 TRANSISTOR, RCA 410 — DELCO DTS 410 |
| Q5 SILICON CONTROL RECTIFIER — G.E. C106841 — RCA 10682 |
| IC-1 INTEGRATED CIRCUIT, 741, OP.AMP. — FAIRCHILD U977741393-NAT.semi.cond NS 307N |

The foregoing is a description of a preferred form of the invention wherein an AC power source is converted via a bridge rectifier 22 to a DC voltage. This DC voltage is regulated by a voltage regulator circuit 27 of the series regulator type to produce at its output 28 a regulated voltage. The regulator circuit 27 itself, however, is switched on and off by a transistorized switch 40 in combination with a mechanical switch 44 located on an electrostatic spray gun 45. Because a transistor switch is utilized, arcing at the mechanical switch 44 located on the electrostatic spray gun is effectively reduced to zero. When the spray gun switch is closed, the regulator circuit 27 produces at its output 28 a regulated voltage which is applied to the power input of an inverter circuit 50. This inverter circuit 50 develops across a secondary transformer winding 60 a high frequency intermediate voltage which is approximately 8Kv. peak-to-peak. This intermediate voltage is connected to the input to a voltage multiplier circuit 12. The output of the voltage multiplier circuit 12 is a very high DC voltage which is connected via a coaxial cable 13 to the probe 14 at the spray gun 15. This high DC voltage is operative to charge the particles sprayed by the spray gun.

An overcurrent detector 70 is provided to detect overcurrent conditions at the spray gun probe 14. Whenever the ground return current from the voltage multiplier 12 to the overcurrent detector 70, which is the probe current, exceeds a predetermined value, the overcurrent detector 70 generates a signal at its output 100 which is operative to cause an overcurrent/over-voltage shutoff switch 52 to shut down the power supply by short circuiting the voltage regulator output 28, short circuiting the input to the inverter circuit 50 and also turning off the regulator 27 itself thereby removing power from the input of the voltage multiplier 12. This overcurrent/over-voltage shutoff switch 52 is also operative to turn off the power supply if the voltage at the power input to the inverter 50 exceeds a predetermined maximum value. The overcurrent/over-voltage shutoff switch 52 also keeps the power supply turned off until such time as the operator has an opportunity to manually reset the power supply by depressing a reset switch 111.

While the foregoing description has been made with particular emphasis on a preferred embodiment of the invention, it will be readily recognized by those of skill in the art that numerous modifications in form only may be made without departing from the spirit and scope of the invention as defined by the following claims.

What is claimed is:

1. A very high voltage power supply for electrostatic spray coating application in which electrostatically charged coating material is sprayed onto a directly electrically grounded object comprising, in combination:

   a source of DC power with a control input and an output, said source producing a DC voltage at said output, said source including a turnoff means responsive to an externally generated turnoff signal applied to said control input for turning off said source thereby removing said DC voltage from said source output;

   an inverter circuit with a DC input and an AC output, said inverter circuit input being connected to receive DC power from said DC source output, said inverter circuit producing at its output an intermediate AC voltage at a high frequency;

   a voltage multiplier circuit with an input and an output, said voltage multiplier input being connected to receive power from said inverter circuit output, said voltage multiplier producing at its output a very high DC voltage for use in electrostatically charging coating material sprayed onto a directly electrically grounded object in electrostatic spray coating;

   an overcurrent detector with an input and an output, said overcurrent detector input being connected to the input of said voltage multiplier circuit to monitor ground return current from said voltage multiplier and producing an overcurrent signal at its output when the current flow from said voltage multi-
A power supply shutdown switch activated in response to said overcurrent signal for simultaneously a) generating and applying said turnoff signal to said overcurrent detector means to thereby turnoff said DC source to said inverter and thereby removing power from the input of said voltage multiplier circuit; and
a remotely controlled electronic switch connected between electrical ground and said control input for selectively producing said turnoff signal; and

a mechanical switch remotely located with respect to said electronic switch, said mechanical switch being operative to control said electronic switch to selectively produce said turnoff signal.

2. A power supply for producing a very high DC voltage for application to a probe of an electrostatic spray gun from which electrostatically charged coating material is sprayed onto a directly electrically grounded object comprising, in combination:

a source of unregulated DC power including an output power lead and a common ground lead, said power lead having an unregulated voltage thereat relative to said common ground lead,

a voltage regulator circuit with a two wire power input, a control input and an output, one input wire of said regulator input being connected to said power lead and the other input wire of said series regulator being connected to said common ground lead, said voltage regulator circuit producing a regulated DC voltage at its output relative to said common ground lead when said control input is at a voltage higher than at said ground lead, said regulator including a turnoff means responsive to an externally generated turnoff signal applied to said control input for turning off said regulator thereby removing said DC voltage from said regulator output;

an inverter circuit with a two wire input and a two wire output, one said inverter circuit input wire is connected to said regulator output and the other inverter circuit input wire is connected to said common ground lead, said inverter circuit producing at its two wire output an intermediate AC voltage at a high frequency;

a voltage multiplier circuit with a two wire input and a single wire output, said two wire input of said voltage multiplier is connected to said inverter circuit two wire output, said voltage multiplier produces at its single wire output a very high DC voltage which is electrically connected to the spray gun probe for electrostatically charging coating material sprayed onto a directly electrically grounded object.